

**MONFRC: Software for the  
Graphical Display of  
Parameters and Data in the  
Low Speed Wind Tunnel Data  
Acquisition System**

Craig D. Edwards

DSTO-TN-0218

19991008 014

**DISTRIBUTION STATEMENT A**  
Approved for Public Release  
Distribution Unlimited

# MONFRC: Software for the Graphical Display of Parameters and Data in the Low Speed Wind Tunnel Data Acquisition System

*Craig D. Edwards*

**Air Operations Division  
Aeronautical and Maritime Research Laboratory**

DSTO-TN-0218

## ABSTRACT

The Data Acquisition System in the Low Speed Wind Tunnel involves the measurement, recording, processing and displaying of wind tunnel test data. As part of this system, a software package called MONFRC was developed to display in real time, all parameters and data relevant to a wind tunnel test. The software was coded using the C programming language with OpenGL and GLUT libraries in the X Windows environment to provide the user with animated graphical gauges. This created a user-friendly interface to assist operators with monitoring wind tunnel information on the screen. Warnings and alarms have been implemented to alert the operator when particular parameters exceed user-defined limits. The contents of the screen can be customised for the type of wind tunnel test being undertaken.

## RELEASE LIMITATION

*Approved for public release*

DEPARTMENT OF DEFENCE	<b>DSTO</b>
DEFENCE SCIENCE & TECHNOLOGY ORGANISATION	

*Published by*

*DSTO Aeronautical and Maritime Research Laboratory  
PO Box 4331  
Melbourne Victoria 3001 Australia*

*Telephone: (03) 9626 7000  
Fax: (03) 9626 7999  
© Commonwealth of Australia 1999  
AR-011-056  
August 1999*

**APPROVED FOR PUBLIC RELEASE**

# MONFRC: Software for the Graphical Display of Parameters and Data in the Low Speed Wind Tunnel Data Acquisition System

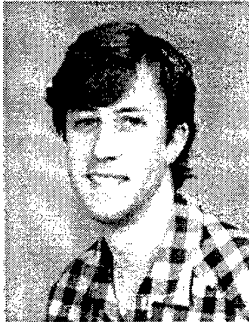
## Executive Summary

The Data Acquisition System in the Low Speed Wind Tunnel at the Aeronautical and Maritime Research Laboratory involves the measurement, recording, processing and displaying of wind tunnel test data. A software package called MONFRC has been developed as part of this system, and it is responsible for displaying all parameters and data relevant to a wind tunnel test in real time.

MONFRC has been coded using the C programming language with OpenGL and GLUT libraries in the X Windows environment to provide the user with animated graphical gauges. This created a user-friendly environment and enabled faster and easier monitoring of wind tunnel information both qualitatively and quantitatively. With this interface, operators are able to quickly monitor the information displayed on the screen and take appropriate and timely actions in accord with the wind tunnel test plan. Warnings and alarms have been implemented to alert the operator when particular parameters exceed user-defined limits. The contents of the screen can be customised for the type of wind tunnel test being undertaken.

This software and the associated upgrades to the Low Speed Wind Tunnel in recent years, will allow the tunnel to be used for Defence purposes with increased productivity and efficiency.

## Authors



**Craig D. Edwards**  
Air Operations Division

*Craig graduated from the University of Queensland in 1995 completing a Bachelor of Mechanical and Space Engineering with First Class Honours. The following year he obtained employment with the Aeronautical and Maritime Research Laboratory at Melbourne. Working in Flight Mechanics, he has gained considerable experience in the area of wind tunnels and experimental aerodynamics including test programmes with the Hydrographic Ship and PC-9/A aircraft. He has also been involved extensively in the development of wind tunnel data acquisition systems.*

---

---

# Contents

<b>1. INTRODUCTION.....</b>	<b>1</b>
<b>2. SOFTWARE REQUIREMENTS AND EXECUTION .....</b>	<b>1</b>
2.1 Software and Display Requirements.....	1
2.2 Directory Structure and Initialisation Files .....	2
2.3 Execution .....	2
<b>3. SOFTWARE OPERATION AND DISPLAY.....</b>	<b>2</b>
<b>3.1 Freestream Parameters.....</b>	<b>4</b>
3.1.1 Wind Tunnel Velocity.....	4
3.1.2 Air Temperature .....	4
3.1.3 Tunnel Test Section Static Pressure .....	6
3.1.4 Dynamic Pressure .....	6
3.1.5 Mach Number .....	6
3.1.6 Reynolds Number.....	8
<b>3.2 Model Attitude and Orientation .....</b>	<b>8</b>
3.2.1 Pitch/Yaw Rig.....	8
3.2.2 Pitch/Roll Rig .....	9
3.2.3 Graphic of the Wind Tunnel Model .....	10
<b>3.3 Strain Gauge Balance Loads .....</b>	<b>10</b>
<b>3.4 Auxiliary Parameters .....</b>	<b>11</b>
<b>3.5 Control Surface Actuators.....</b>	<b>12</b>
<b>3.6 Module Status Alarms.....</b>	<b>13</b>
<b>4. SOFTWARE CUSTOMISATION .....</b>	<b>13</b>
<b>4.1 MONFRC Initialisation File .....</b>	<b>13</b>
4.1.1 Model Type .....	14
4.1.2 Gauge Characteristics .....	14
4.1.3 Display Options .....	15
4.1.4 Colour Options.....	15
<b>4.2 Configuration File.....</b>	<b>16</b>
<b>4.3 Modules Initialisation File .....</b>	<b>16</b>
<b>5. CONCLUSIONS AND FUTURE DEVELOPMENT .....</b>	<b>17</b>
<b>REFERENCES .....</b>	<b>18</b>

## 1. Introduction

The Data Acquisition System in the Aeronautical and Maritime Research Laboratory (AMRL) Low Speed Wind Tunnel (LSWT) involves the measurement, recording, processing and displaying of wind tunnel test data. As part of a recent upgrade of this data acquisition system [Ref 1], new software was required to display all parameters and data relevant to a wind tunnel test in near real time.

From the operator's perspective, a display that contained the necessary information in a graphical form in addition to the data values would be very "user-friendly". This type of interface would enable more accurate, faster and easier reading of wind tunnel data both qualitatively and quantitatively. Operators would be able to quickly monitor the information displayed on the screen and take appropriate and timely actions in accord with the wind tunnel test plan. The implementation of warnings and alarms was also required to alert the operator when particular parameters exceeded user-defined limits.

As a consequence, the software package MONFRC was developed as the primary software to display wind tunnel information. It has been coded using the C programming language with OpenGL and GLUT libraries in the X Windows environment to provide the user with a graphical interface.

This report is intended for a typical tunnel user and describes the operation and functionality of the MONFRC software.

## 2. Software Requirements and Execution

### 2.1 Software and Display Requirements

MONFRC is written in the C programming language using X/Motif libraries and OpenGL/GLUT libraries and operates under a UNIX environment. Compilation of the software uses an *Imakefile*, which allows portability, so that the software can theoretically be recompiled and executed on a different system. The OpenGL libraries enable easy development of animated graphics that were considered to be important for both aesthetic and functional reasons. It provides a user-friendly interface and allows the operator to quickly scan the screen and acquire the necessary information both qualitatively and quantitatively.

The monitor on which MONFRC is to be displayed must be supported by a special graphics card (ZLXp-E3). The system must also support the GLX extension. MONFRC can currently be displayed only on the host computer console screen, which is a DEC AlphaServer 4/233 computer called "BERNOULLI".

## 2.2 Directory Structure and Initialisation Files

For correct operation, MONFRC requires the job directory structure created by DATAIN [Ref 2] for a particular wind tunnel test. In particular, the sub-directories of `./misc` and `./conf` are required. MONFRC must be started in the main job directory and expects three initialisation files located in their respective sub-directories:

1. MONFRC initialisation file, `monfrc.ini`, located in the `./misc` sub-directory
2. Modules initialisation file, `modules.ini`, located in the `./misc` sub-directory
3. Configuration file with extension `.dat`, located in the `./conf` sub-directory

These three files can be modified to customise the display. Their contents and purpose in MONFRC are detailed in later sections of this report.

## 2.3 Execution

The executable file for MONFRC is located in the `~/bin` sub-directory under the home directory of user 'lswt' on BERNOULLI. MONFRC can be started in one of the following three different ways:

1. Typing directly at the prompt in the job directory using a command with the following syntax,

```
monfrc -display bernoulli:0.0 -conf config_filename.dat
```

The switch `-display bernoulli:0.0` can be disregarded if the command is typed at the BERNOULLI console. If the `-conf` switch is ignored, the default configuration file, `conf_new.dat`, will be used if it exists in the `./conf` sub-directory.

2. Manually clicking on the button via the DATAIN user interface [Ref 2] after a job directory has been selected.
3. Automatically, when a new test is started with on-line measurements [Ref 2]. The configuration file chosen for the test will be automatically passed to MONFRC.

In all cases, MONFRC will be displayed on the BERNOULLI console screen.

## 3. Software Operation and Display

MONFRC appears as a single screen with animated graphical gauges that display all parameters relevant to a wind tunnel test, as shown in Figure 1. The gauges are arranged on the screen in logical groups so they can be located and read easily and quickly. The following sections describe these groups and the gauges that each group contains.



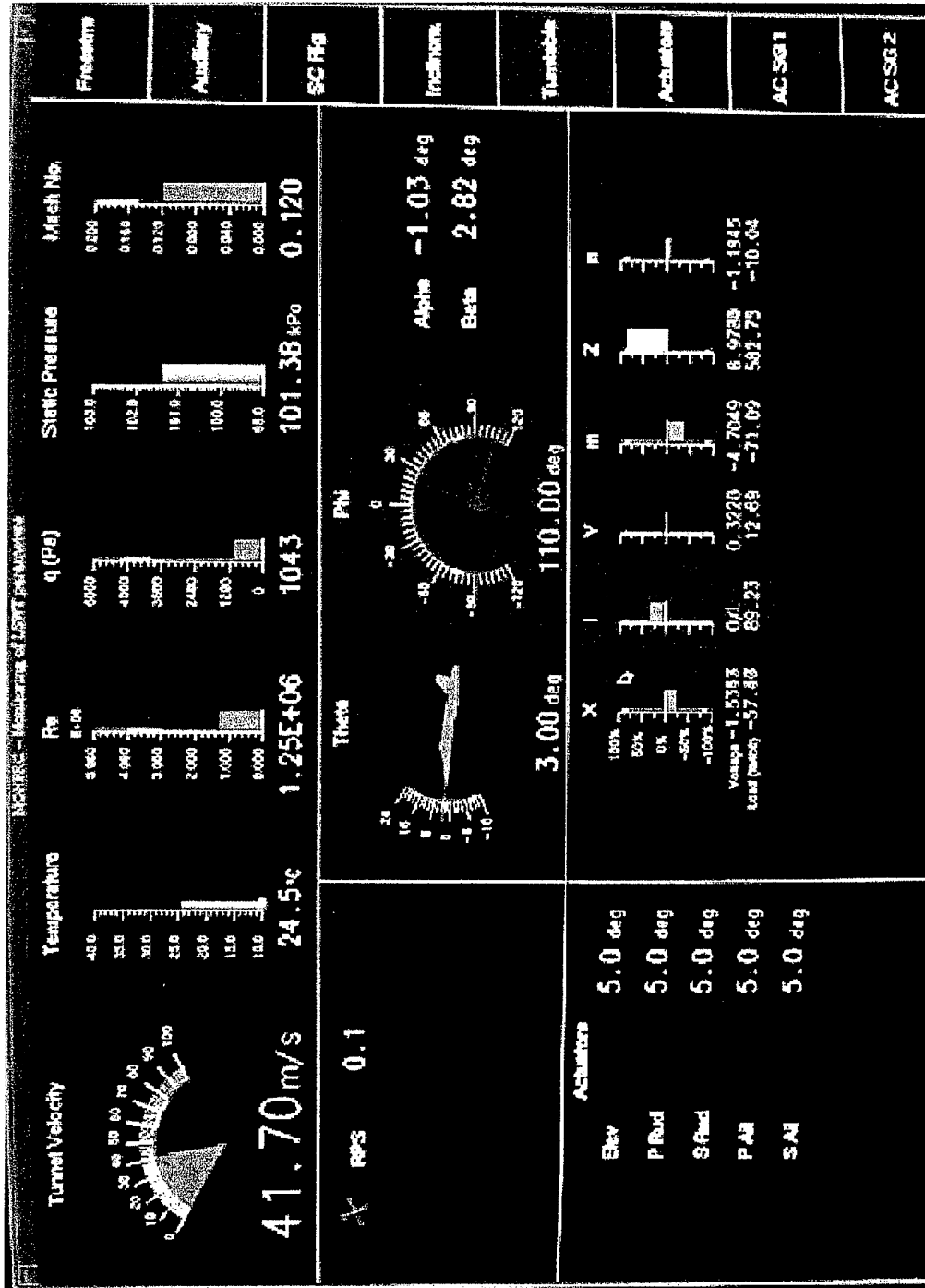


Figure 1. A typical snapshot of the MONFRC screen

### 3.1 Freestream Parameters

The top third of the screen contains the freestream parameters that display the properties of the airflow in the wind tunnel, as shown in Figure 1. A text title above each gauge identifies the data each gauge displays.

#### 3.1.1 Wind Tunnel Velocity

The velocity of the freestream airflow inside the wind tunnel test section is represented by a dial gauge similar to a common vehicle speedometer, as shown in Figure 2. The sector swept out by the gauge needle has a solid colour indicating the warning level defined by the set alarm limits. The velocity magnitude is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur. These are also applicable to other gauges that have warning levels. The alarm limits, warning levels and available colours are detailed in Section 4.1.

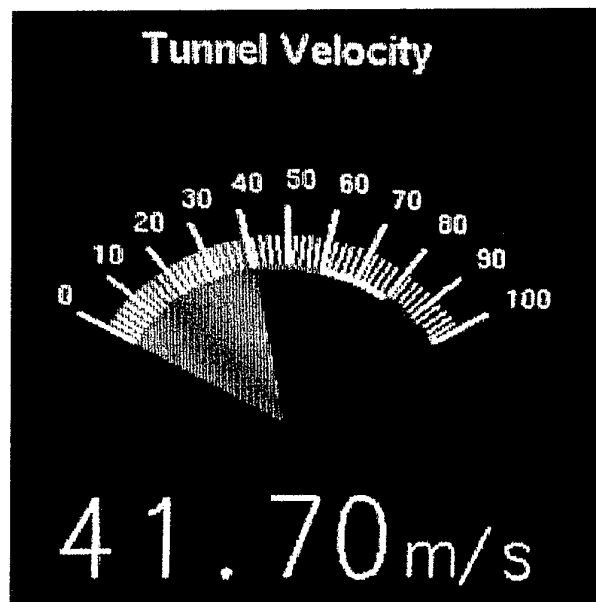


Figure 2. Wind Tunnel Test Section Air Velocity Gauge

#### 3.1.2 Air Temperature

The air temperature in the test section is represented by a bar type gauge that resembles a mercury thermometer, as shown in Figure 3. The temperature value is also displayed in text beneath the gauge. No warning level indicator exists on this gauge. However, the option of a final warning is provided, where a red rectangle is flashed in the background surrounding the gauge when a critical temperature is reached.

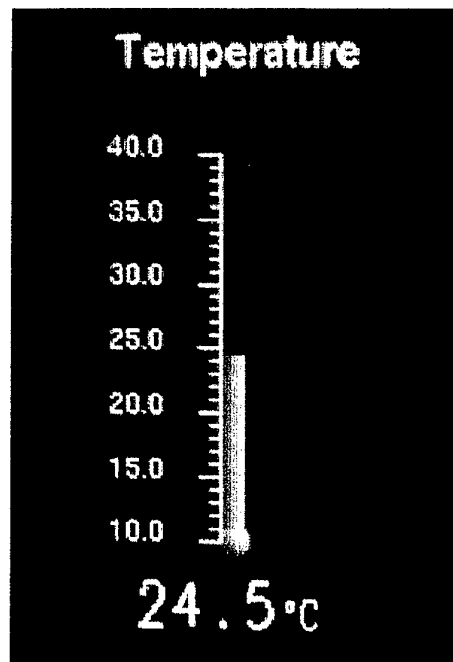


Figure 3. Wind Tunnel Test Section Air Temperature Gauge

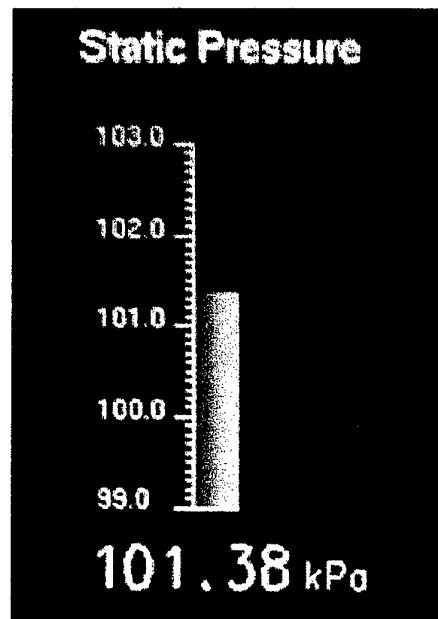


Figure 4. Wind Tunnel Test Section Static Pressure Gauge

### 3.1.3 Tunnel Test Section Static Pressure

The tunnel test section static pressure is represented by a bar type gauge that resembles a mercury barometer, as shown in Figure 4. The pressure value is also displayed in text beneath the gauge. No warning level indicator exists on this gauge. However, the option of a final warning is provided, where a red rectangle is flashed in the background surrounding the gauge when a critical tunnel test section static pressure is reached.

### 3.1.4 Dynamic Pressure

The dynamic pressure ( $q$ ) of the airflow in the tunnel test section is represented by a simple bar gauge, as shown in Figure 5. The colour of the bar indicates the warning level defined by the set alarm limits. The dynamic pressure value is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

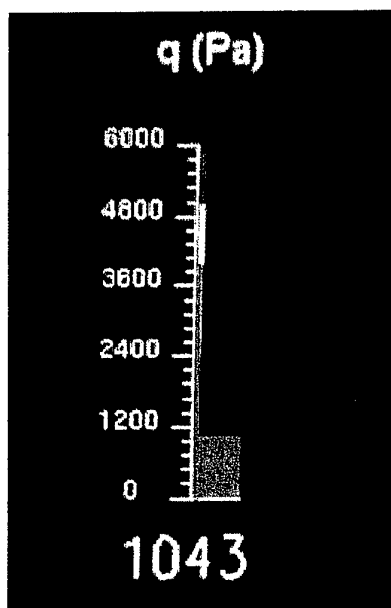


Figure 5. Wind Tunnel Test Section Dynamic Pressure Gauge

### 3.1.5 Mach Number

The Mach number of the flow in the tunnel test section is represented by a simple bar gauge, as shown in Figure 6. The colour of the bar indicates the warning level defined by the set alarm limits. The Mach number is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur. Although Mach Number

is not often used in low speed wind tunnel testing, it is included for completeness and possibly for use in other tunnel applications.

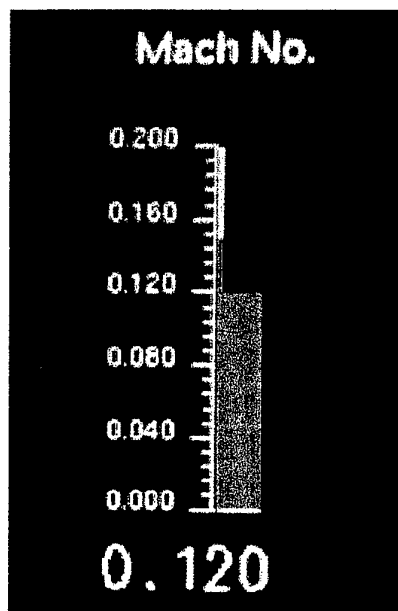


Figure 6. Wind Tunnel Test Section Air Mach Number Gauge

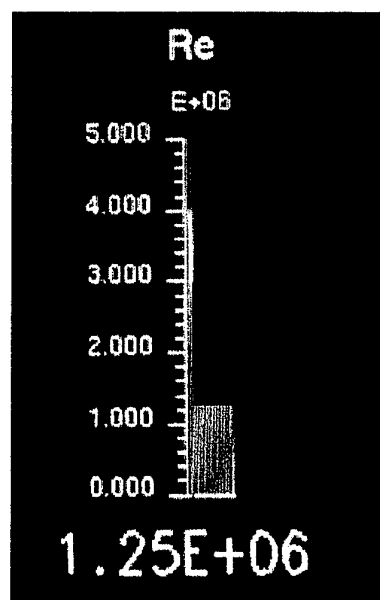


Figure 7. Wind Tunnel Test Section Air Reynolds Number Gauge

### 3.1.6 Reynolds Number

The Reynolds number of the airflow in the tunnel test section is represented by a simple bar gauge, as shown in Figure 7. The colour of the bar indicates the warning level defined by the set alarm limits (although a warning level is not usually needed for Reynolds number). The Reynolds number is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

## 3.2 Model Attitude and Orientation

The model attitude and orientation gauges displayed are dependent on the type of test being undertaken and the rig being used, which are defined in the configuration file (see Section 4.2).

### 3.2.1 Pitch/Yaw Rig

For a pitch/yaw rig, where a model would normally be mounted on a turntable in the LSWT, the orientation information of the wind tunnel model that is important is the angle of attack, Alpha ( $\alpha$ ), and angle of sideslip, Beta ( $\beta$ ).

Figure 8 shows the gauges displaying the model attitude and orientation angles for a pitch/yaw type rig. This replaces the portion of the display with the Theta, Phi gauges observed in Figure 1 (see Section 4.1.3).

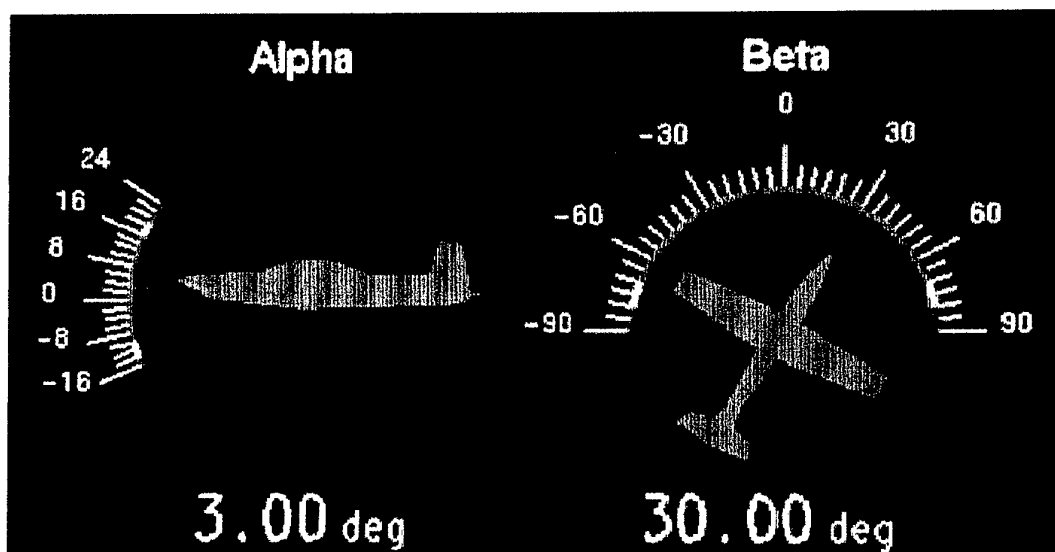


Figure 8. Model Attitude and Orientation Gauges for a Pitch/Yaw Type Rig

The angle of attack ( $\alpha$ ) of the wind tunnel model is represented by a dial gauge with a needle. A side view graphic of the wind tunnel model is also depicted at the centre of the gauge. The colour of this wind tunnel model graphic indicates the warning level defined by the set alarm limits. The value of  $\alpha$  is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

The angle of sideslip ( $\beta$ ) of the wind tunnel model is represented by a dial gauge with a needle. A plan view graphic of the wind tunnel model is also depicted at the centre of the gauge. The colour of this wind tunnel model graphic indicates the warning level defined by the set alarm limits. The value of  $\beta$  is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

### 3.2.2 Pitch/Roll Rig

For a pitch/roll rig, normally called the sting-column rig in the LSWT, the orientation information of the wind tunnel model that is important is the pitch angle, Theta ( $\theta$ ), and roll angle, Phi ( $\phi$ ). For additional information, the calculated values of angle of attack ( $\alpha$ ) and sideslip ( $\beta$ ) are also displayed.

Figure 9 shows the gauges displaying the model attitude and orientation angles for a pitch/roll type rig.



Figure 9. Model Attitude and Orientation Gauges for a Pitch/Roll Type Rig

The pitch angle ( $\theta$ ) of the wind tunnel model is represented by a dial gauge with a needle. A side view graphic of the wind tunnel model is also depicted at the centre of the gauge. The colour of this wind tunnel model graphic indicates the warning level defined by the set alarm limits. The value of  $\theta$  is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

The roll angle ( $\phi$ ) of the wind tunnel model is represented by a dial gauge with a needle. A rear view graphic of the wind tunnel model is also depicted at the centre of the gauge. The colour of this wind tunnel model graphic indicates the warning level defined by the set alarm limits. The value of  $\phi$  is also displayed in text, in a colour associated with the warning level. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur.

Alpha ( $\alpha$ ) and Beta ( $\beta$ ) are also displayed in text. No warning level indicator exists on this Alpha and Beta display. However, the option of a final warning is provided for these two parameters, where a red rectangle is flashed in the background surrounding the appropriate parameter when a critical value is reached.

### 3.2.3 Graphic of the Wind Tunnel Model

For the model attitude and orientation gauges, appropriate graphical views of a wind tunnel model are displayed at the centre of each dial gauge. At present, three representations exist for this model: an F/A-18, a PC-9/A, and a MK-82 Bomb. Examples of the PC-9/A and F/A-18 representations are shown in Figure 8 and Figure 9 respectively. Other types of models can be incorporated with relative ease. The choice of this graphic is controlled by a parameter in the MONFRC initialisation file (see Section 4.1).

### 3.3 Strain Gauge Balance Loads

The strain gauges on a strain gauge balance, usually located inside the model, are used to measure the three aerodynamic forces and moments on the model. On the screen the strain gauge outputs are displayed as a block of 6 strain gauge channels, as shown in Figure 10.

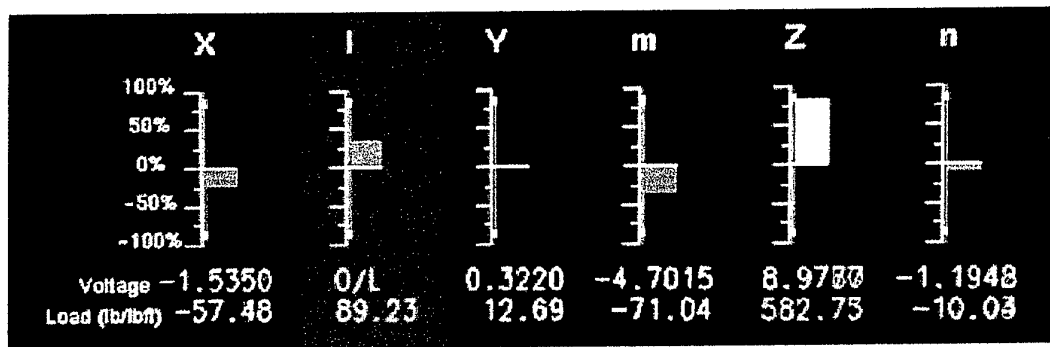


Figure 10. Strain Gauge Balance Force and Moment Measurement on a Wind Tunnel Model

Each individual strain gauge channel is identified by a title and displays the measured data in three ways:



1. Value of the strain gauge voltage signal.
2. Value of the balance load or moment in lb or lbft (or N or Nm), which is derived from the strain gauge output voltage, based on the calibration matrix from the configuration file (see Section 4.2).
3. A graphical bar gauge displaying the balance load as a **percentage** of the balance safe load limit as identified in the configuration file.

The colour of each bar indicates the warning level defined by the set alarm limits. A warning level indicator on the gauge shows the values at which the transitions between warning levels occur. The values of the strain gauge voltage and the balance load also change colour according to the warning level. An overload (O/L) message is displayed if a strain gauge channel amplifier reaches its maximum voltage limit. This may occur before a balance load warning if the balance component was only calibrated over a portion of its safe load range.

Space exists on the screen for a second block of six strain gauge channels, which has been reserved for cases when control surface hinge moment readings are required.

### 3.4 Auxiliary Parameters

At present, a propeller tachometer reading is the only auxiliary parameter represented on the MONFRC screen, as shown in Figure 11. Space exists below this gauge for the display of any additional parameters from the auxiliary module that is required in the future. The value in revolutions per second (RPS) is displayed in text. No warning level indicator exists on this gauge. However, the option of a final warning is provided, where a red rectangle is flashed in the background surrounding the gauge when a critical RPS is reached.



Figure 11. Propeller Tachometer Gauge

A graphic of a spinning propeller is also displayed on the screen for aesthetic purposes and quick identification of RPS information. The speed at which this propeller graphic is rotating does not reflect the true propeller RPS.

### 3.5 Control Surface Actuators

The actuators move and set the control surfaces on a model in the tunnel and the actuator "gauges" display the angle of each control surface. The number of valid actuator channels and the description of each actuator channel are determined by the appropriate section in the modules initialisation file, `modules.ini`. Sufficient space exists on the MONFRC display for eight actuator channels.

Each valid actuator channel is displayed on the MONFRC screen with a control surface description (obtained from the `modules.ini` file) and its angle value in text, as shown in Figure 12. A graphical drawing of each control surface may be developed for identification and to assist in determining the positive direction of movement. Currently, only rudder and elevator actuator graphics for a PC-9/A aircraft model are available, and these are automatically drawn if a PC-9/A is selected as the wind tunnel model type in the MONFRC initialisation file, `monfrc.ini`. These PC-9/A actuator graphics are shown in Figure 13. A detailed description of the setup of the actuators is given in Reference 3.

At present, no warning levels are associated with the actuator gauges.

Actuators	
Elev	5.0 deg
P Rud	5.0 deg
S Rud	5.0 deg
P Ail	5.0 deg
S Ail	5.0 deg

Figure 12. Actuator Readouts for the Control Surfaces of an F/A-18

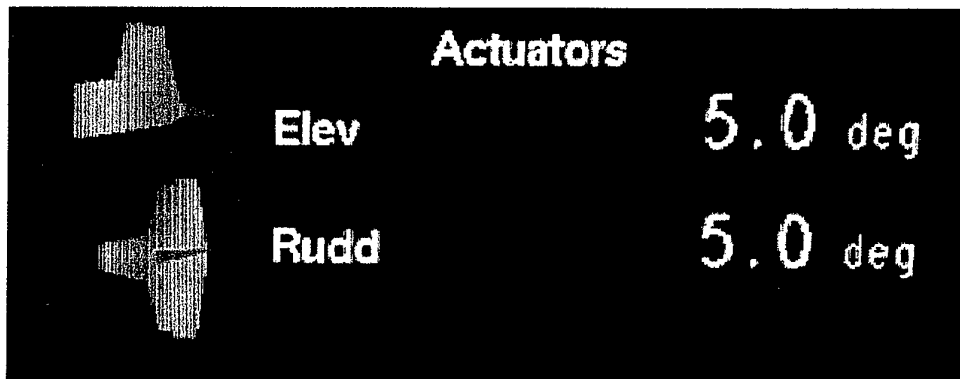


Figure 13. Actuator Readouts for the Control Surfaces of a PC-9/A

### 3.6 Module Status Alarms

The column along the right-hand side of the display, shown in Figure 1, contains a series of module status “buttons”. These simply flash red when a module is not responding or the module data cannot be read from the database. The module status buttons shown as an example in Figure 1, indicate that the turntable and auxiliary modules are not functioning correctly.

## 4. Software Customisation

The MONFRC program relies on the following three files that can be modified to customise the display for a particular type of wind tunnel test:

1. MONFRC initialisation file
2. Wind Tunnel Configuration file
3. Data Acquisition Modules initialisation file

The first two files can be modified through a user-friendly interface with the program WTSETUP [Ref 4]. The initialisation file for the data acquisition modules is usually created at the beginning of a wind tunnel test programme after inclinometer offsets are established and an actuator calibration is performed (if required).

### 4.1 MONFRC Initialisation File

The MONFRC initialisation file, `monfrc.ini`, resides in the `./misc` subdirectory under the job directory from which MONFRC is executed. It is a `ascii` file that contains information regarding the characteristics and properties of the display for the graphical

gauges. All of this information can be modified through a user-friendly interface with the program WTSETUP [Ref 4].

#### 4.1.1 Model Type

The type of wind tunnel model that is involved in the test programme can be chosen from a list using WTSETUP [Ref 4]. At present, the only options are an F/A-18, a PC-9/A and a MK-82 Bomb. This selection enables the appropriate graphics to be displayed with the model attitude and orientation gauges on the MONFRC screen. The PC-9/A option also draws suitable graphical representations of the rudder and elevator control surfaces for the actuator gauges. A programmer familiar with the software can incorporate other wind tunnel models with relative ease.

#### 4.1.2 Gauge Characteristics

The MONFRC initialisation file contains characteristics for the following gauges:

- Velocity - dial gauge
- Temperature - mercury thermometer style bar gauge
- Dynamic Pressure - general bar gauge
- Reynolds Number - general bar gauge
- Mach Number - general bar gauge
- Wind Tunnel Test Section Static Pressure - mercury barometer style bar gauge
- Pitch Angle - side view of wind tunnel model with dial gauge
- Roll Angle - rear view of wind tunnel model with dial gauge
- Yaw Angle - plan view of wind tunnel model with dial gauge
- Additional Angle 1 - text description only
- Additional Angle 2 - text description only
- Strain Gauges 1 - block of six bar gauges
- Actuator Angles - actuator information is obtained from the modules initialisation file
- RPS - text description with spinning propeller graphic

For each individual gauge listed above the following characteristics may be changed:

- **Display ON/OFF** - This controls whether the gauge is to be displayed on the screen. If the gauge is switched OFF, that portion of the screen is blank. This function is intended to remove gauges from the screen that are not required for a particular test and this avoids cluttering of information on the screen.
- **Title or Description** - This is the title or description of the parameter displayed on the gauge and it is written above the gauge. The units of the gauge parameter value may also be included in this text. In particular, the general bar gauges (dynamic pressure, Reynolds Number and Mach Number) do not have units defined so the units must be placed in this description. The description line for the strain gauge balance consists of six individual titles for the six strain gauge channels separated by commas.

- **Lower and Upper Gauge Limits** - The lower and upper absolute limits displayed on the gauge may be set by the operator. If the parameter value is beyond this gauge range, a warning message "Out of Range", or similar, is printed on the screen.
- **Lower and Upper First Warning Limits** - The first warning limit is the value at which the operator receives a first warning that a parameter value is nearing a dangerous level. It indicates that the operator must be watchful of this parameter and careful that a dangerous situation does not develop. Most gauges only have an upper first warning, which is at the high end of the gauge range. Some gauges, such as the model attitude and orientation gauges, may also have a lower first warning limit to alert the operator at both ends of the gauge range. For most gauges the first warning involves a colour change of the gauge and text value to a default of yellow (colours can be modified - refer to Section 4.1.4).
- **Lower and Upper Final Warning Limits** - The final warning limit is the value at which the operator receives a final warning that a parameter value is in a dangerous zone. It indicates that the operator should respond immediately by taking appropriate action to return the parameter value to a safe region and avoid a dangerous situation. Most gauges only have an upper final warning, which is at the high end of the gauge range. Some gauges such as the model attitude and orientation gauges may also have a lower final warning limit to alert the operator at both ends of the gauge range. For most gauge types the final warning involves a colour change of the gauge and text value to a default of red (colours can be modified - refer to Section 4.1.4). In addition, when a final warning limit is exceeded, a red rectangle continually flashes in the background of the entire gauge to attract the operator's attention to that gauge.

### 4.1.3 Display Options

Under normal operation, the types of model attitude and orientation gauges that are displayed are determined by the rig type parameter located in the configuration file (refer to Section 4.2). An option exists to override this function and have the model attitude and orientation gauges displayed according to the definition in the MONFRC initialisation file, `monfrc.ini`.

An option also exists to override the display of actuator gauges as defined in `monfrc.ini` and have them determined from the parameters in the modules initialisation file (refer to Section 4.3).

### 4.1.4 Colour Options

The colours of the following aspects of the MONFRC display may also be changed:

- The background colour of the entire screen.
- The colour of the gauge markings and lines.

- The colours of the graphical gauges at the levels of no warning, first warning and final warning.
- The colours of the digital parameter value at the levels of no warning, first warning and final warning.

These colours can be selected easily via the WTSETUP program interface [Ref 4].

## 4.2 Configuration File

This ascii file with extension `.dat` is associated with a particular type of wind tunnel test configuration and it is created at the beginning of a test programme. Only certain sections of the file affect the operation of MONFRC and only these will be discussed. Further information on the configuration file is given in the WTSETUP report [Ref 4].

The following section describes the parameters in the configuration file that are utilised by MONFRC.

- **Reynolds Number Length** - This parameter is passed to the freestream parameters instrumentation module to ensure the display of the correct Reynolds Number (the Reynolds Number is calculated on the freestream parameters module using the temperature and static pressure values that are acquired by this module).
- **Type of Wind Tunnel Model Rig** - This information (pitch/yaw or pitch/roll) defines the source of the attitude data [Ref 4]. It determines what model angle definitions are to be used for the model attitude and orientation gauges. An option exists to override this function by using the information contained in `monfrc.ini` as described in Section 4.1.
- **Balance Calibration Matrices** - These matrices allow the real time calculations of the balance loads in lb/lbft or N/Nm from the strain gauge voltage readings. The balance loads are displayed on the MONFRC screen for the operator.
- **Balance Safe Loads** - These loads are used to determine the real-time balance loads as percentages of their safe limits. The percentages are displayed on the graphical strain gauges on the MONFRC screen.

All of these parameters can be changed through a user-friendly interface with the program WTSETUP [Ref 4].

## 4.3 Modules Initialisation File

The modules initialisation file, `modules.ini`, resides in the `./misc` subdirectory below the job directory from which MONFRC is executed. It is an ascii file that contains information relevant to each of the LSWT data acquisition modules. MONFRC uses certain sections of this file and only these will be discussed.

- **Turntable Information** - The LSWT has two test sections, each containing a floor and ceiling turntable. If the wind tunnel model is mounted on a turntable,

MONFRC needs to know which turntable it is in order to obtain the correct data. An offset angle for this turntable may also be entered to display the correct model yaw. MONFRC obtains this information from the modules initialisation file. This information is determined at the beginning of a wind tunnel test programme [Ref 2].

- ***Inclinometer Offsets*** - The inclinometer offsets contained in the modules initialisation file are read by MONFRC to ensure the display of accurate orientation angles of the wind tunnel model. These offsets are the pitch and roll zero values that are determined at the beginning of a wind tunnel test programme [Ref 2].
- ***Actuator Information*** - The valid actuator channels and their descriptions are obtained from the modules initialisation file. This information is processed by MONFRC to display the appropriate actuator gauges on the screen. The actuator data in the modules initialisation file is calculated and written to the file during an actuator calibration [Ref 4].

## 5. Conclusions and Future Development

A software package called MONFRC has been developed as part of the Low Speed Wind Tunnel Data Acquisition System and it is used to display all parameters relevant to a wind tunnel test in near real time. Animated graphical gauges are displayed to create a user-friendly environment and to enable faster and easier reading of wind tunnel information both qualitatively and quantitatively. Warnings and alarms have been incorporated to alert the operator when particular parameters exceed user-defined limits. The contents of the screen can be customised according to the type of wind tunnel test being undertaken. This report is intended for a typical tunnel user and it describes the operation and functionality of the MONFRC software.

A test schedule file to semi-automate the wind tunnel runs is currently under development. Once the test schedule file is fully implemented into COMFRC on-line measurements [Ref 2], MONFRC may recognise the setpoints contained in the test plan. Future software development of MONFRC may include implementing warnings on the screen when a certain parameter is not within tolerance of the desired setpoint. This would provide a quick indication to the operator when a line of data should or should not be obtained.

With the vast possibilities of future wind tunnel models and types of wind tunnel tests, limitations of the MONFRC screen display may emerge. This software has been written so that a competent programmer, after becoming reasonably familiar with the software, would be capable of incorporating the required changes with relative ease.

## References

1. Link, Y., Holland, O., Lam, S., (1999), *A New Wind Tunnel Data Acquisition System at the Aeronautical and Maritime Research Laboratory*, Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Department of Defence, Australia, paper presented at the 91<sup>st</sup> Semi-Annual Supersonic Tunnel Association International Meeting.
2. Edwards, C., Lam, S., Link, Y., (to be published), *Performing Low Speed Wind Tunnel Tests Using the New Data Acquisition System*, Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Department of Defence, Australia.
3. Toffoletto, R., (1999), *A New Actuator Control Program for the Low Speed Wind Tunnel*, DSTO-TN-0188, Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Department of Defence, Australia.
4. Edwards, C., (to be published), *WTSETUP: Software for Creating and Editing of Configuration Files in the Low Speed Wind Tunnel Data Acquisition System*, Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Department of Defence, Australia.



## DISTRIBUTION LIST

MONFRC: Software for the Graphical Display of Parameters and Data in the Low  
Speed Wind Tunnel Data Acquisition System

Craig D. Edwards

### AUSTRALIA

#### DEFENCE ORGANISATION

##### Task Sponsor

##### S&T Program

Chief Defence Scientist	}	shared copy
FAS Science Policy		
AS Science Corporate Management		
Director General Science Policy Development		
Counsellor Defence Science, London (Doc Data Sheet )		
Counsellor Defence Science, Washington (Doc Data Sheet )		
Scientific Adviser to MRDC Thailand (Doc Data Sheet )		
Scientific Adviser Policy and Command		
Navy Scientific Adviser (Doc Data Sheet and distribution list only)		
Scientific Adviser - Army (Doc Data Sheet and distribution list only)		
Air Force Scientific Adviser		
Director Trials		

##### Aeronautical and Maritime Research Laboratory

Director

Chief of Air Operations Division

Neil Pollock

Simon Oldfield

David Glenny

Neil Matheson (2 copies)

Author: Craig Edwards (2 copies)

Yoel Link (3 copies)

B. Fairlie	J. Harvey
------------	-----------

S. Lam	H. Quick
--------	----------

R. Toffoletto	S. Leung
---------------	----------

L. Erm	G. Ainger
--------	-----------

M. Glaister	D. Carnell
-------------	------------

J. Clayton	P. Malone
------------	-----------

I. Amott	A. Gonzales
----------	-------------

O. Holland	F. Bird
------------	---------

R. Worl	S. Kent
---------	---------

M. Spataro

**DSTO Library**

Library Fishermens Bend

Library Maribyrnong

Library Salisbury (2 copies)

Australian Archives

Library, MOD, Pyrmont (Doc Data sheet only)

\*US Defence Technical Information Center, 2 copies

\*UK Defence Research Information Centre, 2 copies

\*Canada Defence Scientific Information Service, 1 copy

\*NZ Defence Information Centre, 1 copy

National Library of Australia, 1 copy

**Capability Development Division**

Director General Maritime Development (Doc Data Sheet only)

Director General Land Development (Doc Data Sheet only)

Director General C3I Development (Doc Data Sheet only)

Director General Aerospace Development (Doc Data Sheet only)

**Army**

ABCA Standardisation Officer, Puckapunyal, (4 copies)

SO (Science), DJFHQ(L), MILPO Enoggera, Queensland 4051 (Doc Data Sheet only)

NAPOC QWG Engineer NBCD c/- DENGERS-A, HQ Engineer Centre Liverpool

Military Area, NSW 2174 (Doc Data Sheet only)

**Intelligence Program**

DGSTA Defence Intelligence Organisation

**Corporate Support Program**

OIC TRS, Defence Regional Library, Canberra

**UNIVERSITIES AND COLLEGES**

Australian Defence Force Academy

Library

Head of Aerospace and Mechanical Engineering

Senior Librarian, Hargrave Library, Monash University

Librarian, Flinders University

**OTHER ORGANISATIONS**

NASA (Canberra)

AGPS

## **OUTSIDE AUSTRALIA**

### **ABSTRACTING AND INFORMATION ORGANISATIONS**

Library, Chemical Abstracts Reference Service  
Engineering Societies Library, US  
Materials Information, Cambridge Scientific Abstracts, US  
Documents Librarian, The Center for Research Libraries, US

### **INFORMATION EXCHANGE AGREEMENT PARTNERS**

Acquisitions Unit, Science Reference and Information Service, UK  
Library - Exchange Desk, National Institute of Standards and Technology, US

SPARES (6 copies)

**Total number of copies:        72**

<b>DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION</b> <b>DOCUMENT CONTROL DATA</b>					
				1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)	
2. TITLE  MONFRC: Software for the Graphical Display of Parameters and Data in the Low Speed Wind Tunnel Data Acquisition System			3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION)  Document (U) Title (U) Abstract (U)		
4. AUTHOR(S)  Craig D. Edwards			5. CORPORATE AUTHOR  Aeronautical and Maritime Research Laboratory PO Box 4331 Melbourne Vic 3001 Australia		
6a. DSTO NUMBER DSTO-TN-0218		6b. AR NUMBER AR-011-056		6c. TYPE OF REPORT Technical Note	
7. DOCUMENT DATE August 1999					
8. FILE NUMBER M1/9/613		9. TASK NUMBER 98/179		10. TASK SPONSOR DST	
				11. NO. OF PAGES 18	
				12. NO. OF REFERENCES 4	
13. DOWNGRADING/DELIMITING INSTRUCTIONS				14. RELEASE AUTHORITY  Chief, Air Operations Division	
15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT  <p style="text-align: center;"><i>Approved for public release</i></p>					
OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, SALISBURY, SA 5108					
16. DELIBERATE ANNOUNCEMENT  No Limitations					
17. CASUAL ANNOUNCEMENT Yes					
18. DEFTEST DESCRIPTORS  Computer systems; Data acquisition; Systems; Software; Wind tunnels					
19. ABSTRACT The Data Acquisition System in the Low Speed Wind Tunnel involves the measurement, recording, processing and displaying of wind tunnel test data. As part of this system, a software package called MONFRC was developed to display in real time, all parameters and data relevant to a wind tunnel test. The software was coded using the C programming language with OpenGL and GLUT libraries in the X Windows environment to provide the user with animated graphical gauges. This created a user-friendly interface to assist operators with monitoring wind tunnel information on the screen. Warnings and alarms have been implemented to alert the operator when particular parameters exceed user-defined limits. The contents of the screen can be customised for the type of wind tunnel test being undertaken.					